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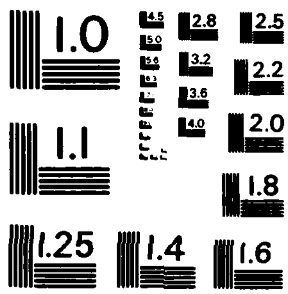

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SPECIAL REPORT NO. 232

AFGL
FISCAL YEAR 1984
AIR FORCE TECHNICAL OBJECTIVES DOCUMENT

NOVEMBER 1982

AIR FORCE GEOPHYSICS LABORATORY
HANSCOM AFB, MASSACHUSETTS 01731

AIR FORCE SYSTEMS COMMAND, USAF

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John Friel

JOHN FRIEL, Colonel, USAF
Commander

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This report comprises the Air Force Geophysics Laboratory Fiscal Year 1984 Technical Objectives Document, and describes the five major thrusts in environmental technology. The environmental areas of concern include optical and space physics, meteorology, aeronomy and terrestrial sciences. In addition, a brief summary of the basic research program is included. This document supersedes AFGL-TR-81-0287.

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INTRODUCTION

The Air Force Technical Objectives Document (TOD) program is an integral part of the process by which the Air Force plans and formulates a detailed technology program to support the development and acquisition of Air Force weapon systems. Each Air Force laboratory annually prepares a Research and Technology (R&T) Plan in response to available guidance based on USAF requirements. the identification of scientific and technological opportunities, and the needs of present and projected systems. These plans include proposed efforts to achieve desired capabilities, to resolve known technical problems, and to capitalize on new technical opportunities. The proposed efforts undergo a lengthy program formulation and review process. Generally, the criteria applied during the formulation and review are responsiveness to stated objectives and known requirements, scientific content and merit, program balance, developmental and life cycle costs, and consideration of payoff versus risk.

It is fully recognized that the development and accomplishment of the Air Force technical program is a product of the teamwork on the part of the Air Force laboratories and the industrial and academic research and development community. The TOD program is designed to provide to industry and the academic community, necessary information on the Air Force laboratories' planned technology programs. Each laboratory's TOD is extracted from its R&T Plan.

Specific objectives are:

a. To provide planning information for independent research and development programs.

b. To improve the quality of the unsolicited proposals and R&D procurements.

c. To encourage face-to-face discussions between non-government scientists and engineers and their Air Force counterparts.

One or more TODs have been prepared by each Air Force laboratory that has responsibility for a portion of the Air Force Technical Programs. Classified TODs are available from the Defense Technical Information Center (DTIC) and unclassified TODs are available from the National Technical Information Service (NTIS).

As you read through the pages that follow, you may see a field of endeavor where your organization can contribute to the achievement of a specific technical goal. If such is the case, you are invited to discuss the objective further with the scientist or engineer identified with that objective. Further, you may have completely new ideas not considered in this document which, if brought to the attention of the proper organization, can make a significant contribution to our military technology. We will always maintain an open mind in evaluating any new concepts which, when successfully pursued, would improve our future operational capability.

On behalf of the United States Air Force, you are invited to study the objectives listed in this document and to discuss them with the responsible Air Force personnel. Your ideas and proposals, whether in response to the TODs or not, are most welcome.

HOW TO USE THIS DOCUMENT

Unsolicited proposals to conduct programs leading to the attainment of any of the objectives presented in this document may be submitted directly to an Air Force laboratory. However, before submitting a formal proposal, we encourage you to discuss your approach with the laboratory point of contact. After your discussion or correspondence with the laboratory personnel, you will be better prepared to write your proposal.

As stated in the "AFSC Guide for Unsolicited Proposals" (copies of this informative guide on unsolicited proposals are available by writing to Air Force Systems Command/PMPR, Andrews Air Force Base, Washington, DC 20334), elaborate brochures or presentations are definitely not desired. The "ABCs" of successful proposals are accuracy, brevity, and clarity. It is extremely important that your letter be prepared to encourage its reading, to facilitate its understanding, and to impart an appreciation of the ideas you desire to convey. Specifically, your letter should include the following:

1. Name and address of your organization.

2. Type of organization (profit, non-profit).

3. Concise title and abstract of the proposed research and the statement indicating that the submission is an unsolicited proposal.

4. An outline and discussion of the purpose of the research, the method of attack upon the problem, and the nature of the expected results.

5. Name and research experience of the principal investigator.

6. A suggestion as to the proposed starting and completion dates.

7. An outline of the proposed budget, including information on equipment, facility, and personnel requirements.

8. Names of any other Federal agencies receiving the proposal. (This is extremely important.)

9. Brief description of your facilities, particularly those which would be used in your proposed research effort.

10. Brief outline of your previous work and experience in the field.

11. If available, you should include a descriptive brochure and a financial statement.

MANAGEMENT OVERVIEW

LABORATORY MISSION

The mission of the Air Force Geophysics Laboratory (AFGL) is to conduct research, exploratory and advanced development programs in the terrestrial, atmospheric, and earth-related space sciences. As a result of this research and development, AFGL scientists and engineers attempt to understand the way that the environment affects the Air Force systems, find ways to mitigate the detrimental effects of the environment on the systems, and where possible, attempt to exploit the properties of the environment - for example, ionospheric modification. To perform this mission, AFGL conducts programs in the areas of missile geophysics, upper atmospheric effects, the optical/IR environment, meteorology and the space environment. Close liaison is maintained with AFSC Product Divisions and with other AFSC Laboratories, in order to identify research and technology needs, and to accelerate the integration of technological advances into Air Force systems and operations.

DIRECTOR'S ASSESSMENT AND INVESTMENT STRATEGY

In recent years, systems engineers have recognized that many advanced USAF surveillance, communications and weapons systems are greatly influenced by a multitude of geophysical factors ranging from earthquake vibration of missile silos to electrostatic charging of communications satellites in synchronous orbit. The mission of the AFGL requires not only that the geophysical environment be studied and understood, but that the interaction between the environment and the system be understood. As a result, deleterious effects on Air Force systems can be mitigated or in special cases, certain geophysical effects can be exploited to enhance a system capability.

AFGL will receive approximately 66% of its FY84 funding from AFSC 6.2 and 6.1 Program Elements (PEs). AFGL is an active participant in the AFOSR-managed 6.1 research program, with 14 tasks in the areas of Chemistry, Terrestrial Sciences, Atmospheric Sciences, and Astronomy and Astrophysics. In addition, AFGL will receive substantial advanced development funding, both from Product Division programs and from AFSC under the AFGL-managed Program Elements of PE 63707F - Weather Systems (Advanced Development), and PE 63410F - Space Systems Environmental Interactions Technology. AFGL also receives funds from DMA, DNA and DARPA for support of programs of mutual interest.

AFGL utilizes five major thrusts to structure and describe the technology efforts that are supported by funds from the various programs described in the previous paragraph. The AFGL thrusts are:

Thrust 1	Space Effects on Air Force Systems
Thrust 2	Optical/IR Systems Technology
Thrust 3	Upper Atmosphere Impact on Air Force Systems
Thrust 4	Terrestrial Effects on Air Force Systems
Thrust 5	Weather Impact on Air Force Mission

In Thrust 1 - Space Effects on Air Force Systems, the major sub-thrusts are Space Radiation, Space Systems/Environment Interactions, and Space Environment Specifications.

Within the Space Radiation area, the characteristics and dynamics of space radiation which affect the survivability and autonomy of space defense and communication systems are studied. The space testing and qualification of advanced microelectronic devices together with the simultaneous measurement of

the actual energetic particle radiation in space is an integral part of this effort. The work is carried out under a joint program with NASA, the Navy and other Air Force organizations. Experimental and theoretical efforts are conducted to develop a space modification capability. The modification of regions of the space environment by means of chemicals, waves, rf heating and particle beams promises to be an important tool for the Air Force and DoD in the 1990s. The payoffs include increased satellite reliability and autonomy, definition of space radiation hazards to astronauts and the ability to control space environment conditions for offense/defense.

In the Space Systems/Environment Interactions Program, the interaction of the space environment with spacecraft is studied and systems-limiting coupling phenomena identified. Computer modeling, interaction processes and environmental specifications for future Shuttle orbits are developed. This work is part of an interdependent Air Force/NASA program for FY81-89 in which AFGL is the lead Air Force agency. Techniques for mitigating or minimizing systems-limiting effects, such as charging, are developed and tested on rocket and Shuttle flights. The geophysical effects of particle beams in space is determined by investigating beam ejections from rockets. Studies are conducted of the effects of beam ejection on the host vehicle, beam propagation, and the magnitude and nature of environmental perturbations produced by beams. The payoff is increased survivability and reliability of future Air Force space systems through the establishment of design guidelines, Mil Standards, and concepts/hardware for the mitigation of systems-limiting effects, including delivery of a space-qualified satellite active charge control system.

Under the Space Environment Specifications effort, the natural environment is calibrated and the dynamics of the space environment characterized. A baseline for energetic charged particles, electric and magnetic fields, currents, and the thermal plasma is derived, and theoretical and statistical models of the magnetosphere/ionosphere system are defined. This work takes into consideration the effects of major solar events, solar flares, solar radio emissions, coronal emissions, energetic solar proton events, and magnetic substorms on the space environment. The work area includes an extensive satellite measurement program to map the space environment, including the electric and magnetic fields and environmental ions and electrons. High latitude currents, particle precipitation, wave-plasma instabilities, and ionization irregularities receive special emphasis because of the importance of the high latitude regions to Air Force communication and detection operations. A major goal is to produce an order of magnitude improvement in the Air Force space environment specifications and forecasting capability which is of importance to the survivability of all Air Force Space Systems, and which is crucial to the effective utilization of Air Force astronauts on future space missions.

In Thrust 2 - Optical/IR Systems Technology, the major sub-thrusts are Atmospheric Transmission, Optical/IR/Nuclear Backgrounds, and Target Signatures.

Within the area of Atmospheric Transmission, computer codes, such as LOWTRAN (low resolution transmission) and HITRAN (high resolution transmission), detailing the transmissivity of optical/IR radiation through the atmosphere, are under development. Extensive data, acquired under the Optical Atmospheric Quantities in Europe (OPAQUE) program, record variations in the optical properties of the lower atmosphere at seven stations in European NATO

countries. These data are being used to develop statistical models and predictive codes for optical transmission in Europe and to refine the LOWTRAN and HITRAN atmospheric codes. This work is directed toward the objectives of the DoD Atmospheric Transmission Plan under which the Air Force has responsibility for developing the DoD standard atmospheric transmission codes. The effort is also devoted to tactical electro-optical (E-O) environment support requirements involving atmospheric transmission of target/background inherent contrast, correlation with meteorological conditions, and support of the development of tactical decision aids for use by the Air Weather Service (AWS) to assist the battlefield commander in determining which E-O/IR weapons to use.

Optical/IR Nuclear Backgrounds programs are underway to determine infrared emissions from all celestial, atmospheric, and terrestrial sources against which optical/IR satellite surveillance and tracking systems must operate. The intensity of the IR radiation from the celestial sphere, zodiacal dust, the aurora and the earthlimb airglow is measured in spectral regions ranging from SWIR (short-wave infrared) to LWIR (long-wave infrared), with particular emphasis on wavelengths of importance for satellite and missile detection, surveillance and tracking applications. Experiments utilizing the Shuttle and satellites will have increasing emphasis. Under the CIRRIS (Cryogenic IR Radiance Instrumentation for Shuttle) program, high spectral and spatial resolution IR measurements of the earthlimb and aurora will be obtained from the Shuttle. In infrared nuclear effects, laboratory studies and field measurement programs focus on the natural aurora and high altitude electron excitation of the atmosphere. Two major laboratory facilities, the COCHISE (Cold Chemiluminescent Infrared Stimulation Experiment) and the LABCEDE (Laboratory Cold Electron-Dependent Emissions) cryogenically-cooled test chambers, are being used to study production and properties of vibrationally-excited atmospheric gases. These laboratory and field measurements find use in nuclear scenario infrared background codes which simulate surveillance system response under nuclear warfare conditions.

To obtain target signature data, a highly instrumented NKC-135 aircraft is used to measure aircraft structure and exhaust plume infrared emission. Spectral, spatial, and temporal variations of the signatures of various types of target aircraft and backgrounds are obtained to meet design input requirements for Air Force systems for tactical and spaceborne detection of aircraft. Specific wavelength bands, aircraft target types, viewing aspect angles, and backgrounds against which the signatures are obtained, are determined in coordinated meetings of DoD agencies involved. High altitude comparisons of submillimeter and long-wavelength infrared capabilities will be emphasized in the future, in both the detection of air vehicles, and the compilation of a data base of atmospheric backgrounds over long range at spatial resolutions appropriate for aircraft detection.

In Thrust 3 - Upper Atmosphere Impact on AF Systems, the major sub-thrusts are Ionospheric Effects on AF Systems, Ultraviolet Technology, Upper Atmosphere Effects, and Aerospace Probe Development.

The principal efforts within Ionospheric Effects on AF Systems include studies of transionospheric location and tracking uncertainties, radio frequency fading and phase effects, and ionospheric modeling, monitoring, prediction, and modification. Theoretical studies and measurement programs are conducted to determine, understand and predict the state of the ionosphere and

its role in enhancing or degrading the performance of Air Force systems. The effects of amplitude and phase scintillations on radio frequencies used by Command, Control, Communications and Intelligence (C^3I) satellites are measured and then modeled for use in design and operation of these systems. A large program is conducted to determine the total electron content and vertical profile in the ionosphere for analytical models and predictive techniques to enhance the performance of satellite navigation and ground-based radar systems.

Ultraviolet Technology is concerned with the UV radiance of the atmospheric background and earthlimb, and of the UV emissions from contaminants from the Shuttle. Measurement platforms include rockets, free-flying balloons, and eventually, the Shuttle. Knowledge of the UV emission from Shuttle contaminants is required in the near term, to design the performance characteristics of sensors operating from the Shuttle. In the long term, these sensors will provide the measurements necessary to understand the propagation conditions which will enhance the operation of communications and radar systems. The objective of measuring the UV background of the earth is to design surveillance systems.

Within the sub-thrust of Upper Atmosphere Effects, the major efforts include studies of the turbulence which affects laser transmission, electrical and aerosol properties, atmospheric drag on orbiting vehicles, and various remote sounding techniques to determine the conditions of the upper atmosphere. From just above the earth's surface to approximately 35 km, the motions and composition of the upper atmosphere are measured, mainly from balloons, and modeled for use in designing Air Force systems. For example, measurements are planned which will determine the effects of turbulence on the operation of high energy laser propagation. Above 35 km, the properties of the atmosphere are determined from sensors on rockets and satellites. These data, which are used to develop tailored analytic and predictive models for operational use, provide knowledge concerning winds, density, turbulence, and temperature of this region. These models include undisturbed and naturally-disturbed conditions, and disturbances, due to the detonation of a nuclear weapon. The design and operation of various Air Force satellites and missiles operating in this environment can be simulated over a wide range of conditions.

The principal efforts in Aerospace Probe Development are directed toward increasing the flight time of the various vehicles. Future research and testing of advanced sensors will require rockets with increased altitude ceilings and balloons, both free and tethered, with longer durations aloft. Advanced power systems for balloons to support these longer payload operations are being designed as are improved pointing and navigation systems to locate, more precisely, future high-resolution instruments. A free-flying platform to support various scientific payloads on the Shuttle is also being investigated.

In Thrust 4 - Terrestrial Effects on Air Force Systems, the major subthrusts are Geodetic and Geophysical Effects, and Earth Motion Effects on Air Force Systems.

Within the area of Geodetic and Geophysical Effects on Air Force Systems, research is conducted on the fundamental earth properties to derive astronomic position, to determine and [illegible]ove the shape of the geoid, and to model the acceleration of gravity. In addition, improved instrumentation is developed to measure various geodetic parameters with increased precision. Now under

development is an interferometric technique based on the Global Positioning System (GPS) which could potentially revolutionize measuring baselines. Studies continue to obtain information about the small-scale variations of the geoid using analyses of satellite orbits. These programs are directed toward meeting the goals of the geodetic and gravimetri contributions to future missile error budgets established by the Defense Mapping Agency.

The goal of the research conducted within Earth Motion Effects on Air Force Systems is to measure and characterize the effects of motions, both natural and those due to nuclear detonation, on various Air Force systems, e.g., the MX. Models of ground motions, due to nuclear detonations, are based on measurements of the propagation of seismic waves associated with earthquakes and controlled detonation of chemical explosives. Various analytic, laboratory, and empirical models will be compared to verify predictions of ground motions at likely MX basing sites. The experience gained from modeling seismic propagation in complex terrain is being used to predict the seismic and acoustic loads on various buildings during Space Transportation System (STS) launches at Vandenberg AFB, CA.

In Thrust 5 - Weather Impact on Air Force Mission, the major sub-thrusts are Weather Effects on Air Force Systems, Weather Effects on Air Force Operations, Weather Hazard Detection and Warning, and Weather Satellite Applications.

Weather Effects on Air Force Systems is concerned primarily with the development of atmospheric models that can be used to describe those weather parameters which affect military communications, surveillance, weapon and reentry systems. Specific models being developed include water and ice cloud models for application to electro-optical and millimeter wave system performance, a boundary layer model for anomalous microwave propagation prediction, and weather simulation models for war-gaming applications. This sub-thrust also includes the development of improved sensors for the measurement of cloud properties for use in improving cloud models as well as in remotely specifying cloud particle characteristics along reentry vehicle trajectories for nosecone erosion testing applications.

In Weather Effects on Air Force Operations, the main objectives are to improve the Air Force's ability to define and predict atmospheric variability in time and space through the development, evaluation, and refinement of (1) moist numerical prediction models for global applications, (2) objective and/or man-interactive techniques for regional or local area applications, and (3) the technology to gather required weather information in battle areas not under friendly control as well as at tactical airfields.

Weather Hazard Detection and Warning is concerned with the automated detection and/or prediction of both natural and man-made atmospheric events which present hazards to Air Force systems, operations and personnel. This includes (1) the development of remote sensing techniques for the automated detection and warning of natural hazards, such as turbulence, lightning, wind shear, tornadoes and heavy precipitation; and (2) the development of techniques to predict the atmospheric transport and diffusion of man-made events, such as accidental spills of toxic chemicals, toxic exhausts from rocket launches, and chemical warfare releases.

In Weather Satellite Applications, the primary purpose is to develop weather satellite remote sensing techniques, and to devise improved methods for processing, analyzing, depicting and utilizing weather satellite data for Air Force applications, such as analyses and forecasts for strategic and tactical reconnaissance and strike missions. A major effort in this thrust will be the development of techniques to assimilate satellite data directly into numerical prediction models. Also, the usefulness of new types of weather satellite data will be evaluated using an automated three-dimensional cloud analysis program.

Major FY84 anticipated payoffs in the following specific areas are:

(1) In the area of Space Environment Specification, a worst-case, high-latitude substorm environment will be defined and made available to space systems designers. This will be an essential input to the assessment of auroral beam impact on the Air Force Shuttle operations from Vandenberg AFB, CA.

(2) In the area of atmopsheric transmission, a major milestone will be the production of a report defining the climatology of infrared transmittance on the European continent. Based on the analysis of a three-year record of data from a comprehensive measurement program entitled Optical Atmospheric Quantities in Europe (OPAQUE), the report will be of direct use in developing tactical decision aids for field commanders selecting guided munitions.

(3) In the area of ultraviolet applications, an auroral and ionospheric mapping sensor will be flown on a Space Test Program satellite, as part of a DNA experiment to study the effects of high-latitude ionospheric disturbances on satellite-to-ground communications. Results of this experiment will determine whether or not auroral and ionospheric information can be collected, during both day and night, to specify disruptive effects on Air Force Command, Control, Communications and Intelligence (C^3I) systems.

(4) In the area of gravity and geodetic measuring techniques, the Miniature Interferometric Terminal for Earth Surveying (MITES) should be well on the way to satisfying the performance requirements for a survey instrument. Additionally, significant progress will be made toward the successful design of a land-based gravity gradiometer system.

(5) In the area of weather satellite applications, satellite data will be assimilated directly into a numerical prediction model for the first time, and the impact assessed of using satellite data, as opposed to the currently used conventional data. This a vital step toward developing the procedures needed to assure that weather analyses and forecasts can still be made in the event of hostilities, when conventional weather data will be denied from many critical areas of the world.

Future AFGL efforts will continue to focus on the five technology areas as defined in the thrust structure. In the Space Effects on Air Force Systems, it is expected that the major emphasis will be on the impact of the natural space environment on satellite operations and lifetimes. Work in the Optical/IR Systems Technology will emphasize improving the accuracy and running speed of the AFGL standard atmospheric transmission codes and their ability realistically to represent inclement weather and other limited transmission conditions. Also, emphasis will be on developing improved measurement techniques, in response to more severe requirements to detect extremely weak target signatures against an infrared background that is currently a limiting factor in overall systems performance. These techniques will concentrate on obtaining sensitive data on the limiting infrared backgrounds, as well as selected targets, and the generation of accurate predictive models and codes. In Upper Atmosphere Impact on Air Force Systems, emphasis will be placed on developing satellite remote sensing instrumentation and techniques for determining upper atmospheric parameters affecting Air Force operations; for example, sensing upper atmospheric density and composition using lidars, and sensing ionospheric structure by monitoring upper atmospheric ultraviolet emissions. In Terrestrial Effects on Air Force Systems, major emphasis will be placed on the development of instruments and techniques utilizing satellites for rapid acquisition of needed geodetic and gravitational quantities. In Weather Impact on Air Force Mission, there will be increased emphasis on developing cloud physics and boundary layer models; expanding the climatology program to include weather simulation modeling; and seeking better ways to utilize satellite data for both numerical weather prediction applications and three-dimensional cloud analyses.

RELATIONSHIP OF THE LABORATORY PROGRAMS TO OTHER EFFORTS

AFGL is currently involved in a number of interdependent programs that take advantage of the specific interests and requirements of the participating agencies, while at the same time reducing overall cost. Some typical examples of programs in which AFGL is involved are: ICBM (MX) support with BMO (AFGL providing geophysical data for design requirements); STS (AFGL providing seismic measurements for system design requirements for ground support facilities); DMSP with AWS and SD (AFGL providing satellite sensors and analysis techniques); TEAL RUBY with DARPA and SD (AFGL providing aircraft IR signatures and target management); with AFATL and AFWAL to develop Tactical Decision Aids (AFGL having overall responsibility and providing atmospheric transmission codes); Space Forecasting with AWS (AFGL providing rf environment prediction techniques); MSMP and BAMM with SD (AFGL providing small rocket plume signatures and staring sensor backgrounds at high altitudes); Infrared Backgrounds with SD and NRL (AFGL providing rocket-borne sky and earthlimb IR background measurements); CIRRIS with the SD Space Test Program (AFGL providing sensors for auroral and earthlimb background measurements from the Space Shuttle); and the joint agency Next Generation Weather Radar (NEXRAD) development with NOAA, FAA, and AWS (AFGL providing computer algorithms for tornado detection and warning, hail prediction, severe storm tracking and wind shear). A major new direction is the AF/NASA interdependent program on Spacecraft Environment Interactions in which AFGL plays the major AF role. This program, begun in FY81 and extending to FY89, will develop the technology for controlling the interactions of spacecraft systems with the space environment.

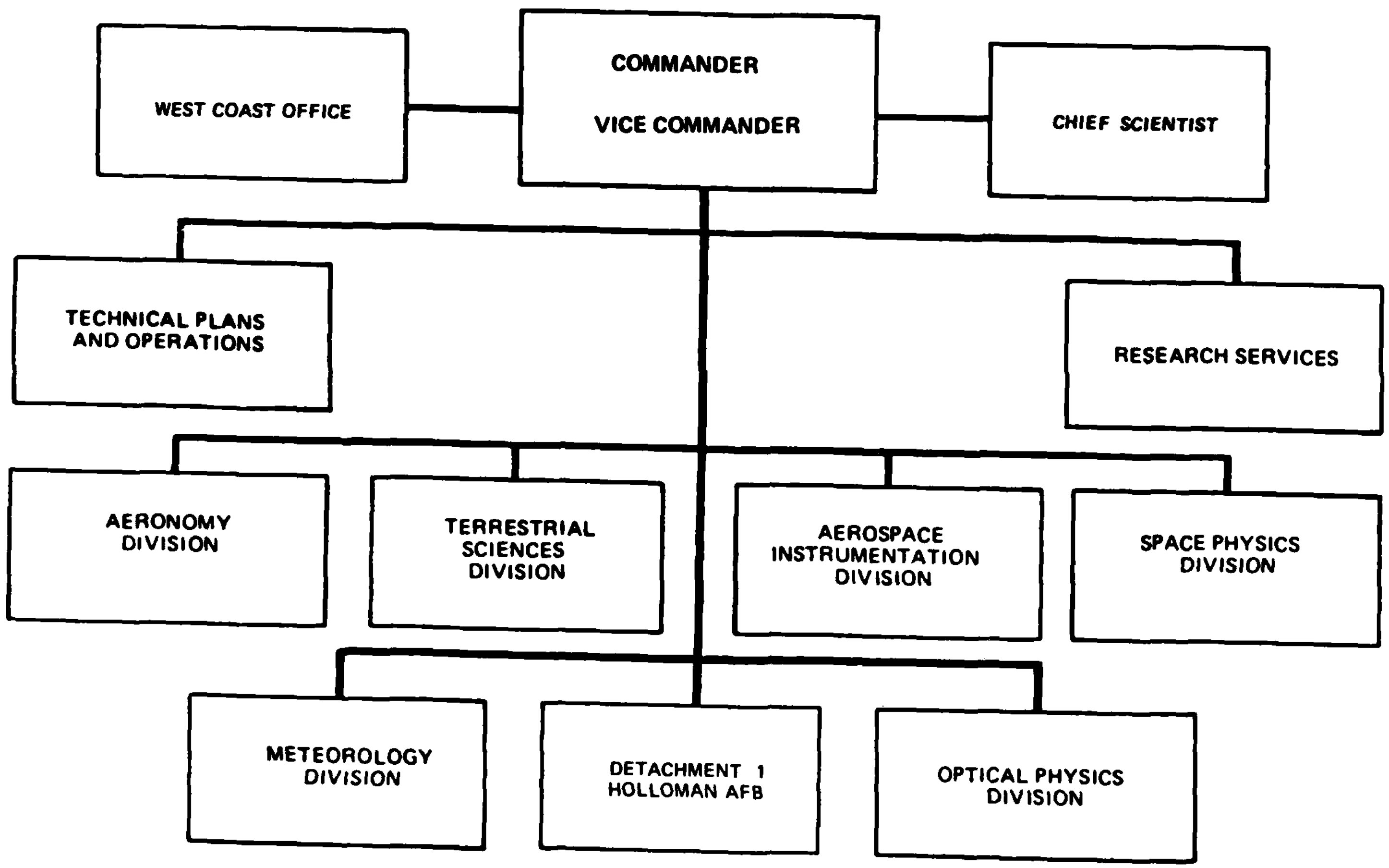
AFGL provides a wide variety of direct support to many AF systems. These include: ASMS and MX at BMO; DSP, STS, DSCS, SBSS, MV, DMSP, GPS, and SSS at SD; OTH-B, AWDS, WWMCCS, SEEK SKYHOOK, and SEON at ESD; PGMs at AD; and Maverick and B1 at ASD. AFGL also provides technical assistance to many AF operational organizations such as SAC, ADCOM, AFCS, AWS, TAC and AFLC, as well as significant support to other DoD agencies such as the Defense Mapping Agency (DMA) and the Defense Nuclear Agency (DNA).

Regarding the Independent Research and Development (IR&D) Program, significant efforts are geared toward application of Optical/IR Systems Technology. The increase in IR&D efforts in large space structures promises broader industrial support in this area, which is a significant part of the future program for the AFGL thrust entitled Space Effects on Air Force Systems.

ORGANIZATION

As shown on the accompanying organizational chart, the Air Force Geophysics Laboratory consists of six Divisions organized according to scientific disciplines, two staff directorates, the office of the Chief Scientist, a Detachment 1 at Holloman Air Force Base, New Mexico, and a West Coast Office which is collocated with the Space Division (SD) in California.

Air Force Geophysics Laboratory



TECHNOLOGY PROGRAM

The objective of the AFGL Geophysics technology program is to develop the capability to predict, mitigate and exploit the effects of the geophysical environment on the design and operational deployment of AF electronic, space and aeronautical systems. The performance of virtually all AF systems is affected adversely by such geophysical phenomena as magnetospheric storms, earthquakes, severe storms, clouds, ionospheric disturbances, aurora, etc. To meet the increasingly stringent AF systems requirements of improved reliability, higher accuracy and survivability, extended remote coverage and minimum life cycle cost, the geophysical environment is being addressed as an integral and interacting part of the system itself.

The program in Geophysics is divided into five thrusts which are:

Thrust 1	Space Effects on AF Systems
Thrust 2	Optical/IR Systems Technology
Thrust 3	Upper Atmosphere Impact on AF Systems
Thrust 4	Terrestrial Effects on AF Systems
Thrust 5	Weather Impact on AF Mission

Under PE 62101F, AFGL has nine Exploratory Development projects which are:

4643	Ionospheric Specification
6670	Meteorological Development
6687	Middle Atmosphere Effects
6690	Upper Atmosphere Technology
7600	Terrestrial Sciences
7601	Magnetospheric Effects on Space Systems
7659	Aerospace Probe Technology
7661	Spacecraft Environment Technology
7670	Optical/IR Properties of the Environment

Also, AFGL has two major Advanced Development efforts which are:

(1) Under PE 63410F - Space Systems Environmental Interactions Technology, there are three projects:

2821 - Space Systems Design and Test Standards
2822 - Interactions Measurement Payload
2823 - Charge Control System

(2) Under PE 63707F - Weather Systems (Advanced Development), there are two projects:

2688 - Battlefield Weather Systems
2781 - Next Generation Weather Radar

This AFGL technology program is conducted in-house as well as at various contractor facilities, and is described briefly under the thrusts on the following pages.

THRUST 1: SPACE EFFECTS ON AIR FORCE SYSTEMS

GENERAL OBJECTIVE: The general objective of this thrust is to define the impact of the earth's space environment on Air Force systems and to achieve the capability of predicting, mitigating, and exploiting the occurrence and intensity of space environmental disturbances which disrupt or degrade Air Force operational systems. A growing activity is the development of the capability of controlling portions of the space environment by means of chemical, wave, and beam injections, and also by ground-based, high power rf and microwave transmitters. Significant effort is placed on the development of space sensors required to conduct the data acquisition work of this thrust.

SPECIFIC GOALS AND TECHNICAL APPROACHES: Within this thrust, there are three major sub-thrusts:

(1) In Space Radiation, the goal is to determine the intensity and variation of the space radiation environment in order to be able to predict and counter its effects on AF systems. Solar particles produce drastic variations in the near-earth radiation environment. The prediction of the magnitude and druation of these perturbations is also a goal of this effort. Experimental and theoretical studies are being conducted in order to provide the understanding and expertise necessary to develop a space modification capability. The payoff, attained by mapping the radiation environment and space-testing microelectronic devices, is the employment of advanced microelectronics in spacecraft with shielding selected to be optimum for specific missions. In FY84, instruments for the space radiation (SPACERAD) payload and other space missions will be fabricated, tested, calibrated and delivered to the satellite contractors. The experiments for SPACERAD include devices to measure the high energy electrons and ions composing the radiation belts; dosimeters and microdosimeters to determine the amount of radiation reaching the interior of a spacecraft; a sophisticated microelectronics package to determine the effects of the radiation on the performance and lifetime of microelectronic components, and wave and plasma devices to determine the dynamics of the radiation belts. The Long Duration Exposure Facility will be launched with an experiment to determine the integrated flux of radiation in a low-altitude equatorial orbit. Also, work will be completed on computer and laboratory simulations of processes in the magnetosphere causing substorms and affecting the intensity of the radiation belts. In FY85, a determination will be made of the feasibility of inducing substorms, or modifying the intensity of the radiation belts by artificial means. In addition, work will be completed on techniques for predicting the occurrence of solar proton events and other major solar terrestrial perturbations. These events seriously degrade the operation of Air Force space systems and are hazardous to astronauts operating on the Shuttle in polar orbit. A program will be undertaken to transfer these prediction techniques to AF operational systems. In the outyears, considerable effort will be placed on the analysis of the SPACERAD data. The results will contribute to the rapid transfer of new microelectronic technologies to AF space systems. The feasibility of active control of portions of the environment by means of waves, beams and chemical injection will be investigated. New approaches will be sought which will produce major improvements in the ability of the Air Force to predict energetic proton events.

(2) In Space Systems/Environment Interactions, there are two major efforts. The first is to develop the technology to control the interaction of large/high-power space structures with the space environment; to identify systems-limiting physical processes and coupling mechanisms in the space environment; and to develop techniques for mitigating systems-limiting effects on mission spacecraft. This work is part of an interdependent AF/NASA program for FY81-89 on Spacecraft Environment Interactions in which AFGL plays the major role for the Air Force. The payoff is increased survivability and reliability of AF space systems, by providing design guidelines/Mil Standards and concepts/hardware for mitigation of systems-limiting effects. In FY84, a worst-case, high-latitude substorm environment will be defined and made available to space system designers. A breadboard model for automating an active charge control system, which will mitigate spacecraft charging problems, will be laboratory tested. In FY85, the computer modeling development efforts will be extended to include physical processes important at high latitudes, in order to expand applicability to polar orbiting spacecraft, including the Shuttle with military astronaut extra-vehicular activities. Critical design reviews will be completed for an Interactions Measurement Payload for Shuttle (IMPS) and the automatic active charge control system. The second major effort is to define the geophysical effects of particle beams in space by studying ejection from spacecraft, the modeling of beam propagation in the space environment, and the interactions with the environment and other systems. A combined theoretical and experimental approach will be taken. Payoffs are anticipated in improved beam ejection efficiencies from space vehicles, improved survivability/reliability of space beam systems and the recognition/identification of hostile beam threats. In FY84, a sounding rocket, instrumented to study the effects of charged particle beam ejection on the rocket vehicle, the charged particle beam itself, and the ambient environment, will be launched. In FY85, the rocket flight data will be analyzed and applied, along with theoretical and laboratory results, to the use of high energy particle beams on space vehicles. In the outyears, the Shuttle environment interaction computer codes will be completed and transferred to space system designers. An automatic charge control system for mission spacecraft will be flight tested. The development of an Interactions Measurement Payload for a polar orbiting Shuttle will be completed and flown in FY89. Major advances are expected in the technology associated with the emission of particle beams from orbiting space vehicles. The investigations will include both effects on a host vehicle and the environmental factors influencing the propagation of beams in space.

(3) In Space Environment Specification, the principal efforts include analytical and experimental studies directed toward the definition and prediction of the magnetosphere-ionosphere system, of hazardous space environments, satellite-induced potential and plasma distributions, and space plasma properties. Supporting solar research is required for the development of solar disturbance forecasting and codes for the prediction of major solar emissions, such as solar flares and intense coronal emissions. Also, the development of advanced space sensors is needed to define the space environment, such as instruments for the measurement of electrostatic waves, electric fields, environmental plasma, electric currents, and magnetic fields, which are used as diagnostic tools for space modification investigations. Another effort is the development of the first numerical model of magnetospheric dynamics. This effort is crucial to the specification and prediction of magnetospheric disturbances, such as magnetic storms and substorms, which can cause catastrophic failures of space communication systems.

The high-latitude regions of the space environment, including the auroral zone and polar cap, receive special emphasis in the satellite data-gathering programs and analytical efforts. The payoffs are the realization of an early warning capability for solar flare and auroral disturbances to spacecraft systems, the production of reliable magnetospheric substorm models, and the determination of high-latitude characteristics in a nuclear-like environment. In FY84, an auroral electron and proton atlas will be produced and transferred to space communication systems designers. A magnetospheric substorm model will be completed and delivered to the Defense Meteorological Satellite Program (DMSP) and to Air Force organizations responsible for providing space forecasts for operational systems. Instruments required to measure and monitor space environment properties for Shuttle and AF satellites will be completed. New space data will be obtained from DMSP satellite flights. Sensors will be flown on Shuttle flights to determine the wake, sheath, electrical and chemical contamination produced by the Shuttle. These measurements are crucial to the utilization of the Shuttle for space defense. In FY85, global scintillation and ionospheric irregularity structure codes will be completed and incorporated into Air Force space forecasting and prediction codes. These codes will be based on the analysis and synthesis of electric field, plasma, energetic particle and wideband data from the joint AF/DNA High Latitude (HILAT) Satellite Program. The major objective of the effort is to determine the mechanisms responsible for the production, evolution, transport and decay of high-latitude irregularities which produce scintillations. In the outyears, the numerical magnetospheric model will be completed and applied to the real-time prediction of substorms. The complex polar environment will be modeled, and codes developed for the prediction of communication system upsets in the auroral zones. Satellite and space station sensors will be developed for monitoring environmental particles hazardous to AF systems and people operating in space. An active satellite program will be pursued which focuses on obtaining data vital to the development, survivability, and autonomy of AF satellites.

THRUST 2: OPTICAL/IR SYSTEMS TECHNOLOGY

GENERAL OBJECTIVE: The general objective of this thrust is to measure and predict the optical and infrared geophysical environment and its effects on Air Force and DoD surveillance, reconnaissance, and weapons guidance systems. The environmental properties of particular concern are the optical/IR background emissions of the earth, the atmosphere, the celestial sky and near-earth space, and the transmissivity of the atmosphere at wavelengths pertinent to operational systems.

SPECIFIC GOALS AND TECHNICAL APPROACHES: Within this thrust, there are three major sub-thrusts.

(1) In Atmospheric Transmission, principal efforts include studies of atmospheric optical/IR measurements, transmission modeling and predictive code development. In atmospheric optical/IR measurements, in FY84, the Transportable Optical Atmospheric Data System (TOADS) will deploy to various CONUS locations to study optical/IR transmission under specific adverse weather conditions such as snow, rain, fog and heavy haze. Surface measurements of visible and IR transmittance and scattering will be supplemented by measurements of aerosol size distribution, aerosol extinction and traditional meteorological variables. Radiative transfer models will be extended into the millimeter region. A major report will be produced defining the climatology of infrared transmittance on the European continent. It will be based on a three-year record of data from the eleven sites of the Optical Atmospheric Quantities in Europe (OPAQUE) measurement program. In FY85, measurements made under documented adverse weather conditions will continue and the development of remote sensing techniques will begin, based on results validated by earlier slant path transmission measurements. In transmission modeling and predictive code development, in FY84, emphasis will be on the continued extension and improved accuracy of the LOWTRAN and HITRAN transmission models. LOWTRAN will incorporate new band model parameters for uniformly mixed gases, and the FASCODE procedure will be applied to non-LTE (local thermodynamic equilibrium) atmospheric radiance problems. Millimeter wave transmission measurements will be used to validate or modify existing millimeter transmission models. Also, development of a tactical decision aid for millimeter wave systems will begin. In FY85, band model parameters for atmospheric trace gases will be incorporated into LOWTRAN, and a general optical turbulence model will be developed. Emphasis in out-years will continue to be on improving the accuracy and running speed of the atmospheric transmission codes and their ability realistically to represent inclement weather and other limited transmission conditions.

(2) In Optical/IR/Nuclear Backgrounds, principal efforts include studies of long wavelength infrared (LWIR) backgrounds, short wavelength infrared (SWIR) backgrounds, and nuclear backgrounds. In LWIR backgrounds, in FY84, a high altitude rocket probe will measure the infrared radiance of the earthlimb in selected bands to help determine the diurnal variation of atmospheric clutter radiance at the level of an initial data base. A celestial measurement will complete the coverage required for the AFGL sky catalog at its present sensitivity level. Development of advanced Cryogenic Infrared Radiance Instrumentation for Shuttle (CIRRIS) will continue in FY85 and beyond. These instruments will obtain detailed spectral and spatial infrared structure of the earthlimb, airglow and aurora. The objective is to enable modeling of the seasonal, geographic and temporal variations of the infrared emissions from

the atmosphere. These data are required to provide the critical design criteria for advanced space and missile/aircraft/tactical surveillance, detection and tracking satellite and intercept systems being developed for deployment before and during the 1990s. In SWIR backgrounds, in FY84, the data from the Earthlimb Infrared Atmospheric Structure (ELIAS) rocket measurements of auroral and airglow emissions will be analyzed and modeled to provide a background clutter predictive capability. The refurbished and redesigned field-widened interferometer spectrometer will be launched into a sunlit aurora to identify radiating species produced only under sunlit conditions. In nuclear backgrounds, in FY84, the EXCEDE series of rocketborne electron accelerator experiments designed to simulate optical and infrared atmospheric effects, induced by high altitude nuclear detonations, will continue. EXCEDE SPATIAL, a follow-on experiment, will be studied for the feasibility of measuring plasma radiation. This is a mother-daughter payload configuration which also measures the spatial profile of ultraviolet, visible and infrared emissions induced in the night atmosphere by a 100 kW electron accelerator. In FY85, the EXCEDE spatial flight will take place and planning will continue to provide greater dosing levels, more sophisticated flight profiles, and LWIR spectral, spatial, and temporal measurements. In both FY84 and 85 and beyond, modeling of the dominant processes producing IR backgrounds in representative surveillance and tracking system bands will be carried out for natural and nuclear backgrounds, using available data. Existing coding will be augmented to meet system needs. Testing will be conducted as part of continuing system stress simulation programs.

(3) In Target Signatures, the principal effort is the measurement of aircraft and tactical target infrared signatures and the natural background radiation against which the target signatures are observed. Observations are made from a highly instrumented NKC-135 aircraft at all aspect angles, in order to address requirements for spaceborne, air-to-air, and ground-to-air detection systems. In FY84, infrared measurements (2.0 to 14 micrometers) of airborne, ground-based and missile targets will be obtained from the NKC-135 aircraft. The infrared properties of targets at long ranges will be observed with the use of telescopic foreoptics to establish the contrast of targets appropriate to the new spatial detection systems, such as mosaic sensors. Measurements of terrain and cloud backgrounds in the submillimeter wavelengths will be planned, in order to better establish the practicality of target detection in this wavelength region. In addition, there will be participation in the detailed planning of ground truth and target placement exercises in support of the Teal Ruby experiment. In other areas of this part of the program, the first of the High Performance Target Engine Measurements (HPTEM) is scheduled to occur and provide the first definitive measurements of plume-atmosphere interaction radiation at close range under controlled conditions. A flight in the Balloon Altitude Mosaic Measurements (BAMM) program will take place, with emphasis expected to be on data obtained over water and of moving clouds at low solar scattering angles. In FY85, the flying infrared laboratory will begin high altitude comparisons of submillimeter and long wavelength infrared effects in the detection of aircraft targets. A data base of atmospheric backgrounds over long ranges and at spatial resolution appropriate for aircraft detection will begin to be compiled. For the Teal Ruby experiment, calibrated verification data on backgrounds and targets and precision target positioning will be provided. The second of the High Performance Target Engine Measurements on a simulated post-boost vehicle engine is scheduled. Further measurements of targets and background phenomena will be conducted in the following years.

THRUST 3: UPPER ATMOSPHERE IMPACT ON AF SYSTEMS

GENERAL OBJECTIVE: The research conducted within this thrust defines the physical and chemical characteristics of the earth's upper atmosphere which extends above the earth from about ten to a few hundred kilometers. The Air Force requires this knowledge for the efficient design and effective employment of AF systems and vehicles which operate in or are affected by this region, and to determine the environmental effects of such vehicles.

SPECIFIC GOALS AND TECHNICAL APPROACHES: Within this thrust, there are four major sub-thrusts:

(1) In Ionospheric Effects on AF Systems, principal efforts include studies of transionospheric location and tracking uncertainties, rf fading and phase effects, and ionospheric modeling, monitoring, prediction, and modification. In transionospheric location and tracking uncertainties, in FY84, preliminary analysis of phase scintillation effects on Space-Based Radar will be refined and developed. In rf fading and phase effects, in FY85, polar experimental studies will be analyzed and extended to determine at what point in the declining portion of the solar cycle major effects cease to be present, and to identify the phenomena occurring in polar regions which are responsible for effects on AF systems. In FY84, using a DNA beacon satellite in conjunction with the incoherent scatter radar in Greenland, measurements of naturally- and artificially-produced ionospheric irregularities will begin. In ionospheric modeling, monitoring, prediction, and modification, the relationship between auroral oval and polar cap parameters will be measured, studied, and modeled in FY85. This knowledge will lead, by FY88, to improved mid-to-high latitude ionospheric models for AF applications, such as OTH surveillance and communications. In FY84, the rationale for predicting the effects of geomagnetic storms on the ionosphere will be developed. In FY85, work will proceed on tractable elements of such a model. Data obtained during experiments employing ionospheric modification from ground-based rf emitters and controlled rocket burns will be analyzed in FY84 and 85 to understand why natural and man-made ionospneric disturbances disrupt AF C^3I systems. By FY86, chemical release experiments will begin to develop further techniques for ionospheric modification.

(2) In Ultraviolet Technology, the principal efforts are (1) surveillance and remote sensing and (2) spacecraft horizon sensing. For surveillance and remote sensing, in FY84, the satellite sensor Auroral/Ionospheric Mapper (AIM), AFGL-101, will be flown on the Space Test Program/Defense Nuclear Agency high latitude (HILAT) satellite. The goal of this experiment is to provide a proof-of-concept of day and night UV auroral location and intensity monitoring to determine if UV imaging can significantly improve the ability of Air Weather Service to specify auroral effects on AF C^3I systems. In addition, the AIM sensor will support the DNA propagation measurements to study scintillations at high latitudes. In FY85, a mid-latitude rocket program will obtain measurements for developing new remote sensing methods of the ionosphere using airglow and solar radiation. This effort continues to improve communications and radar systems by developing new methods to sense remotely the ionosphere from space. By FY87, the surveillance sensor will be ready for flight testing. For spacecraft horizon sensing, in FY84, instrumentation for the satellite experiment Horizon Ultraviolet Program (HUP), AFGL-801C, will be

completed and tested for delivery and integration. The experiment will be flown on a satellite, as arranged for by the Space Test Program. The sensor will provide earth horizon radiance measurements to improve satellite attitude sensors. A second sensor will be developed by late FY85, with a flight planned by early FY87.

(3) In Upper Atmosphere Effects, principal efforts include studies of turbulence affecting laser systems, stratospheric electrical and aerosol properties, atmospheric effects on orbital vehicles, upper atmosphere measurements and density models for AF systems, and laser sounding technology. In turbulence studies, in FY84, a series of daytime and nighttime observations of the variation of the index of refraction with altitude will be made using the newly-developed stellar scintillations. These measurements will be compared with index of refraction measurements made using existing instrumentation. In FY85, the statistics of the frequency of variation in space and time of the index of refraction will be modeled for use in designing laser weapons and communication systems. A handbook of turbulence models will be available by FY86. In electrical and aerosol properties, in FY84 and 85, extensive measurements of stratospheric ions will be made covering several latitudes. In FY84, models of stratospheric ion and aerosol composition will be developed. These models will be used in designing AF systems which transmit rf and optical signals through the stratosphere. New techniques will be developed in FY84 and 85 to detect chemical and biological agents in the environment with an alarm system design beginning by FY86. Environment models will be developed for Shuttle launch at Vandenberg AFB, CA. The hydrochloric plume from Titan III launches will be tracked in FY84 in preparation for tracking Shuttle launches in FY85. In upper atmosphere measurements, in FY84, rocket measurements will be made as part of MAP-WINE (Middle Atmosphere Program - winter in northern Europe) at Andoya, Norway during a sudden stratospheric warming and during normal winter conditions. A technique to infer the dynamics of the upper atmosphere will be completed in FY84. This technique is based on the interpretation of MST (mesosphere, stratosphere, troposphere) radar measurements, based on simultaneous rocket measurements. In FY85, rocket measurements will be made of atmospheric properties in the polar cusp under disturbed conditions to provide important information of optical/IR backgrounds in this unique region. In FY84, a three-dimensional thermospheric model, including chemistry and turbulent heating rates and transfer coefficients, will be developed. During FY84 and 85, the satellite accelerometer density and wind data from satellite instruments SETA #5 and #6 will be added to the AFGL data base and a self-consistent dynamic model of thermospheric winds and density, including storm effects, will be completed. In FY84, testing will be completed of a set of comprehensive upper atmosphere models based on density, optical and incoherent scatter data for recommendation to the COESA (U.S. Committee on Extension to the Standard Atmosphere) and in FY85, the manuscript for a new edition of the U.S. Standard Atmosphere Supplements will be completed. In laser sounding technology, ground-based LIDARs (light detection and ranging) will be developed to probe the properties of the upper atmosphere. In FY84, the mobile LIDAR sounder will be completed and used to support BMO reentry tests at Kwajelein Missile Range, by accurately measuring the density and winds along the reentry path. During FY85, LIDAR measurements will be made to support LASERCOM (laser communications) tests by determining the structure and optical turbulence in the paths between the satellite and aircraft or ground. A balloon-borne LIDAR is being developed, and a first flight is scheduled for FY84. A second flight will be made in FY85, and a report prepared by FY86 on

density and aerosol profiles and cloud data. The balloon-borne LIDAR is a prototype for a satellite LIDAR, which is planned to provide, by FY88, global measurements of stratospheric and upper tropospheric properties.

(4) In Aerospace Probe Development, principal efforts are directed toward improving balloon and sounding rocket technology. Two efforts will be underway in FY84 to increase the flight time of tethered balloons. Both solar cells and powered tethers are being studied as alternatives to power systems currently being used. In FY85, a program will be completed for mobile tethered balloon operation. A pointing control system design, which will orient large payloads suspended from tethered balloons, will be completed by FY86, and available for testing in FY88. Also a navigation system will be designed in FY86, and tested in FY87, for use on free balloons to determine more precisely their location during flight. Improvements in the capabilities of sounding rocket systems will continue throughout the period. These changes are necessary to extend the duration of flight in the exoatmosphere for making infrared measurements. Present plans are directed toward supplementing the single-stage Aries I with a higher performance, two-stage guided sounding rocket by FY88. Since the Shuttle is about to become a routine platform from which to conduct a wide range of experiments in space, a reusable standardized support system is being investigated to reduce integration time and cost. This system would operate independently of the Shuttle itself, and could be used as a free-flying platform to support various scientific experiments. The prototype system could be ready for testing by FY85, with an operational system developed by FY87.

THRUST 4: TERRESTRIAL EFFECTS ON AIR FORCE SYSTEMS

GENERAL OBJECTIVE: The general objective of this thrust is to advance technology in the areas of geodesy, gravity and earth motions in a manner conducive to the resolution of Air Force problems in navigation, guidance, inertial testing and motion sensitive instrumentation. Programs for determining the size, shape, gravity field and motions of the earth are directed toward the assessment of terrestrial effects on missile operations.

SPECIFIC GOALS AND TECHNICAL APPROACHES: Within this thrust, there are two major sub-thrusts.

(1) In Geodetic and Geophysical Effects on Air Force Systems, there will be major improvements in the methods of geodetic first-order position measurement. The techniques employing radio interferometry will, by FY85, offer two very promising ways to make positional measurements. Very Long Baseline Interferometry (VLBI), using quasars as the radio sources, will be a precise method of bying together intercontinental geodetic networks and monitoring variations in earth rotation and polar motion. Because radio telescopes are the receivers for this technique, these observatories will increasingly become main-scheme geodetic stations in national and international networks, including the DoD World Geodetic System. Within the FY85-86 time frame, the Miniature Interferometric Terminal for Earth Surveying (MITES) will evolve into an ubiquitous, easily transportable system for making first-order geodetic measurements. This system will give the Air Force significant advantages over present geodetic position determination methods. The MITES will observe the carrier signals of Global Positioning System (GPS) NAVSTAR satellites. It will not require knowledge of the GPS codes to determine baseline vectors with ultimate precisions of 1 cm for short ($\sim$1 km) baselines and 10 cm for long ($\sim$5000 km) baselines. Each position determination will require no more than two hours measurement, and only a few minutes for data reduction. Stations need not be intervisible, and measurements may be made under all weather conditions and, as GPS becomes operational in FY87 and 88, at any time of day. Used at VLBI observatories, where there are excellent timing standards, and where the earth's rotation will be monitored with high precision, the NAVSTAR satellites will be tracked with a precision of 20 cm. This tracking capability will be extendable to all other satellites with downlink telemetry, without having to understand their signals.

Within the FY84-87 time frame, improved techniques for measuring astronomic positions from stellar observations will be developed and demonstrated. These techniques will involve an automated instrument for observing stars (probably an astrolabe) and a two-color refractometer. By FY88, inertial measurement techniques will mature to a state that they will be capable of measuring azimuth and astronomic latitude with geodetic precision.

By FY86, AFGL will have developed two moving-base gravity gradiometers. One of these will be used in an aircraft, and one will be used in a ground vehicle. Precise observations of gravity gradients will permit a more detailed description of the earth's gravity field. Airborne gravimetry will also become feasible as GPS becomes operational.

Significant progress is expected in determining the geoid and gravity field from bathymetry and the geology of the oceanic crust and mantle. During FY84 and 85, data will be collected from GEOSAT, a DoD geodetic satellite dedicated to measuring the ocean geoid with high precision. GEOSAT data, when combined with existing SEASAT and other geodetic information, will provide a very detailed data base from which the geoid, gravity field and ocean tides will be calculated (FY85-88) in non-polar regions with high resolution.

(2) In Earth Motion Effects on Air Force Systems, ground motion measurements will continue at selected locations to determine the far- and near-field ground transfer characteristics. Between FY84 and 86, these data will be compared to theoretical predictions to define ground motion attributes at varying distances from the source as a function of source type, range, crustal structure and geology. Application of areal calibration methods using network seismic techniques will be developed by FY85 to locate surface sources by path matched filtering. These techniques have direct application to MX deception, seismic surveillance, physical security, and acoustic source locations. Research will be extended into high frequency seismic wave propagation, with its additional complexities caused by considerable scattering and demanding instrumentation requirements, but with payoffs of enhanced resolution and discrimination. By FY87, seismic tomographic techniques will be developed to image the subsurface and determine physical properties at depth.

Ground motion, caused by earthquakes or surface explosions, poses a hazard to land-based Air Force systems, because of potentially destructive ground motion, and degradation of inertial guidance system performance, caused by the passage of seismic waves. Ground motion, induced by either kind of source, is strongly influenced by the nature of the medium in which the waves travel. Complicated geological and topographic structures can cause focusing and scattering of seismic waves and conversion from one kind of wave to another. By FY85, three techniques (seismic ray tracing, Kirchoff integral and finite element modeling) will become available to study these effects in areas of Air Force interest. By FY84, laboratory modeling of ultrasonic waves will provide an independent assessment of the expected motion in selected areas. Between FY84 and 85, seismic hazard studies and direct modeling of ground motion will be directed to assessing the earthquake hazards on surface and buried structures. Knowledge of wave propagation in complex terrains will be applied to predicting acoustic and seismic loads induced by Space Transportation System (STS) launches at Vandenberg AFB, CA, no later than FY85.

Long-period and transient motions from surface loading, tectonics, hydrological and meteorological phenomena, and other causes affect the calibration, testing, and operation of a number of sensitive surveillance, communication, and weapon systems. The spatial and temporal properties of these are poorly known, and instrumentation to reliably measure such motions is just being developed. Theoretical and experimental work will continue in several locales to predict and measure earth deformation. Joint agency testing of sensors, including the AFGL long-base tiltmeter, will continue through FY84 at the Pinon Flat Crustal Deformation Observatory in southern California. Rotational motion sensors, to operate in strong linear motion fields, will be developed by FY86. Techniques will be investigated in FY84 to map subsurface physical properties and detect deep fractures from surface measurements. Repeated GPS VLBI measurements will be made to assess their reliability and detect possible earth motions through FY85.

THRUST 5: WEATHER IMPACT ON AIR FORCE MISSION

GENERAL OBJECTIVE: The general objective of this thrust is to develop improved instrumentation and techniques for measuring, processing, analyzing, modeling and predicting meteorological properties which impact the Air Force mission. Emphasis is on improved cloud physics, boundary layer and weather simulation models for AF systems applications; improved global and regional numerical weather prediction models, automated mesoscale analysis and prediction techniques, and battlefield weather observing and forecasting techniques for AF operations applications; improved ground-based and airborne remote sensing and analysis techniques for weather hazard detection and warning; and improved satellite sensing and data analysis techniques for application to numerical weather prediction and three-dimensional cloud analyses.

SPECIFIC GOALS AND TECHNICAL APPROACHES: Within this thrust, there are [illegible] major sub-thrusts.

(1) In Weather Effects on Air Force Systems, principal efforts include atmospheric model applications and systems design climatology. In atmospheric model applications, the objective is to describe and specify, through cloud models and boundary layer models, those parameters which affect the design and operation of military communications, surveillance, weapon and [illegible] systems. In FY84, ray trace models will be expanded to allow spatial variabilities in the boundary layer refractive structure; development of fast response instruments will be initiated to measure the turbulent refractive index structure in support of troposcatter communications systems; and aircraft tests of a liquid water content meter will be conducted. In FY85, an integrated microphysical mesoscale cloud model, as well as anomalous propagation prediction techniques, will be completed. In FY86, a research-level boundary layer model will be completed and by 1988, adapted for use at Air Force Global Weather Central (AFGWC). In systems design climatology, the objective is to develop weather simulation models and climatological techniques for application to Air Force systems design and operation. In FY84, research in modeling clouds and visibility will be expanded to include additional atmospheric elements to provide a mesoscale environmental simulation model for simulating a realistic sequence of weather events at a specific location. This model will allow environmental factors to be considered in the design of weapon systems and for application to war games. In FY85, the revision to the military standard for climatic extremes (MIL-STD-210B) will be completed. The revision will be tailored to provide distributions of regional atmospheric extremes needed for design and operation of military equipment planned for use only in specific regions of the world. In FY86, a joint weather simulation model will be developed that will give realistic representations of weather event sequences at more than one location simultaneously. Beyond FY86, surface wind climatology models and global cloud climatologies from satellite data will be developed.

(2) In Weather Effects on Air Force Operations, principal efforts include weather prediction and battlefield weather systems. In weather prediction, the objectives are to improve the Air Force's ability to define and predict atmospheric conditions through the development, evaluation and refinement of numerical prediction models for global applications, and objective and/or man-interactive techniques for regional or local area applications. In FY84, improved methods for incorporating boundary layer processes, radiative trans-

fer and cumulus convection will be tested in the global models, and regional numerical prediction model development will begin. Doppler and conventional radar data will be incorporated into local area forecast techniques; aircraft icing forecast models will be flight tested; and numerical short-range humidity/cloud forecast models, using geosynchronous satellite and moisture fields, will be evaluated. In FY85, the global moist numerical model will be validated, and efforts begun to transfer the model to AFGWC by 1987. In FY86, interactive forecast procedures will be field tested and if successful, transitioned to AWS base weather stations for operational use. Beyond FY86, the regional moist numerical model will be validated and transferred to AFGWC. In battlefield weather systems, the objective is to develop techniques to observe and retrieve weather data from battle arenas not under friendly control, and to develop tactical decision aids (TDAs). These data provide input for use by battle staff planners and air crews to insure effective employment of conventional or precision-guided munitions under battlefield conditions. In FY84, TDAs for laser designators and visible wavelength systems will be completed. Also, weather sensor prototypes will be integrated into systems packages to satisfy requirements for tactical employment. In FY85, design specifications for a battlefield weather observing system will be completed, with system integration finalized by the end of FY86, and testing by the end of FY88.

(3) In Weather Hazard Detection and Warning, principal efforts include remote sensing of weather hazards, and toxic chemical diffusion. In remote sensing of weather hazards, the objective is to develop automated remote sensing techniques to detect and warn of atmospheric hazards, ıch as high winds, tornadoes, lightning, turbulence, wind shear, and heavy precipitation, in order to minimize costly damage to Air Force systems, operations and personnel. Many of the techniques being developed will be adapted for use in the joint agency (AF, NOAA, FAA) Next Generation Weather Radar (NEXRAD). In FY84, adverse weather algorithms, such as wind velocity profiling, convective and stratiform convergence/divergence estimation, and storm tracking, will be tested for their applicability to the more common non-tornadic storms. In FY85, there will be an operational test of these algorithms in the Boston area, with participation by the potential government users of NEXRAD information. Also, in FY85, an airborne lightning warning detection system will be completed for use as a lightning avoidance system by Air Force pilots. Beyond FY85, plans include the development of a system to remotely sense regions of high aircraft icing potential, as well as a sensor that will detect reentry weather hazards. In toxic chemical diffusion, the objective is to develop improved techniques for the prediction of the transport and diffusion of toxic chemical releases in the atmospheric boundary layer for use in determining areas downwind that will be subjected to toxic chemicals that may exceed established limits for operational and personnel safety. These releases may be a result of chemical warfare, accidental spills, or toxic exhaust from rocket launches. In FY84 and 85, efforts will concentrate on the development of heavy gas and chemical warfare diffusion models, as well as the continued development of a boundary layer model. Beyond FY85, efforts will be directed toward refinement, testing, evaluation and validation of the various models.

(4) In Weather Satellite Applications, the primary objective is to develop techniques for the remote sensing of meteorological data from satellites, and to devise improved methods for processing, analyzing, depicting, and utilizing weather satellite data for Air Force operational applications, e.g., strategic and tactical reconnaissance and strike missions. In FY84,

satellite data will be assimilated into the AFGL numerical prediction model, and initial testing of the usefulness of weather satellite data for weather analysis and prediction will begin. Also, new weather satellite data will be evaluated, using the AFGL version of the AFGWC three-dimensional cloud analysis program, and an assessment of the feasibility of inferring water vapor profiles from a satellite microwave sounder system will be completed. In FY85, the usefulness of multispectral satellite data will be evaluated, using AFGL's McIDAS (Man-computer Interactive Data Access System). Beyond FY85, the utility of microwave imager data will be evaluated, moisture sounding data will be assessed, and the usefulness of combining visible, infrared, and microwave satellite data will be evaluated.

RESEARCH PROGRAM

RESEARCH PROGRAM

The AFGL research program is strongly focused on the environmental sciences with funding coming from PE 61102F, Subelements 3, 9, 10, and 11 in the areas of Chemistry, Terrestrial Sciences, Atmospheric Sciences, and Astronomy and Astrophysics. The AFGL research activity is conducted in-house as well as at various contractor facilities.

AFGL has 14 basic research task plans which are:

2303G1	Upper Atmosphere Chemistry
2303G2	Plume Atmosphere Interactions
2309G1	Geodesy and Gravity
2309G2	Crustal Motion Studies
2310G1	Molecular and Aerosol Properties of the Atmosphere
2310G3	Upper Atmosphere Composition
2310G4	Infrared Atmospheric Processes
2310G6	Remote Ionospheric Mapping
2310G7	Atmospheric Dynamic Models
2310G8	Advanced Weather Satellite Techniques
2310G9	Global Ionospheric Dynamics
2311G1	Energetic Particles in Space
2311G2	Magnetospheric Plasmas and Fields
2311G3	Solar Environmental Disturbances

These task plans are directly responsive to the following six AFSC Research Objectives:

(1) Subarea 3.1 - Space Effects on Air Force Systems - Research is conducted to obtain an understanding of significant environmental conditions that affect survivability and reliability of satellite sensors and electronics as well as the propagation conditions for communications and radar systems.

(2) Subarea 3.2 - Optical/IR Environmental Research - Research is conducted to support the optimization of the design and performance of military systems operating in both quiet and perturbed atmospheric environments.

(3) Subarea 3.3 - Upper Atmosphere Research - Research is conducted to define the physical and chemical properties of the earth's upper atmosphere and ionosphere, and to determine the effects of such properties on Air Force systems operating therein.

(4) Subarea 3.4 - Terrestrial Effects on Air Force Systems - Research is conducted to develop geodetic and geophysical techniques and instrumentation necessary for the support of Air Force systems (surveillance, reconnaissance, target acquisition, and weapon delivery).

(5) Subarea 3.5 - Weather Effects - Research is conducted to specify and predict meteorological factors which pose threats and/or opportunities to sub-orbital Air Force vehicles and operations.

(6) Subarea 7.1 - Reconnaissance and Surveillance - Research is conducted to detect, identify, locate, count or investigate weapons, personnel, vehicles, installations, lines of communication or other features or activities by visual, photographic, electro-optical, microwave, electronic and other sensing methods.

LIST OF ABBREVIATIONS

AD	Armament Division
ADCOM	Air Defense Command
AFATL	Air Force Armament Laboratory
AFCS	Air Force Communications Service
AFGWC	Air Force Global Weather Central
AFLC	Air Force Logistics Command
AFWAL	Air Force Wright Aeronautical Laboratories
AIM	Auroral/Ionospheric Mapper
ASD	Aeronautical Systems Division
ASMS	Advanced Strategic Missile System
AWDS	Automated Weather Distribution System
AWS	Air Weather Service
BAMM	Balloon Altitude Mosaic Measurements
BMO	Ballistic Missile Office
C^3I	Command, Control, Communications and Intelligence
CIRRIS	Cryogenic IR Radiance Instrumentation for Shuttle
COCHISE	Cold Chemiluminescent Infrared Stimulation Experiment
COESA	U.S. Committee on Extension to the Standard Atmosphere
CONUS	Continental United States
DARPA	Defense Advanced Research Projects Agency
DMA	Defense Mapping Agency
DMSP	Defense Meteorological Satellite Program
DNA	Defense Nuclear Agency
DOD	Department of Defense
DSCS	Defense Satellite Communications System
DSP	Defense Support Program
ELIAS	Earth-Limb Infrared Atmospheric Structure
E-O	Electro-Optical
ESD	Electronic Systems Division
EXCEDE	Electron Seeding Experiment
FAA	Federal Aviation Agency
GPS	Global Positioning System
HILAT	High Latitude
HITRAN	High Resolution Transmission
HPTEM	High Performance Target Engine Measurements
HUP	Horizon Ultraviolet Program
ICBM	Intercontinental Ballistic Missile
IR	Infrared
IR&D	Independent Research and Development
LABCEDE	Laboratory Cold Electron-Dependent Emissions
LASERCOM	Laser Communications
LIDAR	Light Detection and Ranging
LOWTRAN	Low Resolution Transmission
LTE	Local Thermodynamic Equilibrium
LWIR	Long-Wave Infrared
MAP-WINE	Middle Atmosphere Program - Winter in Northern Europe
McIDAS	Man-Computer Interactive Data Acquisition System
MITES	Miniature Interferometric Terminal for Earth Surveying
MSMP	Missile Surveillance Measurements Program
MST	Mesosphere, Stratosphere, Troposphere

LIST OF ABBREVIATIONS (Cont)

MV	Miniature Vehicle
MX	Advanced Intercontinental Ballistic Missile
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NEXRAD	Next Generation Weather Radar
NOAA	National Oceanic and Atmospheric Administration
NRL	Naval Research Laboratory
OPAQUE	Optical Atmospheric Quantities in Europe
OTH-B	Over-the-Horizon Backscatter Radar
PE	Program Element
PGM	Precision Guided Munitions
RF	Radio Frequency
SAC	Strategic Air Command
SBSS	Space-Based Surveillance System
SD	Space Division
SEON	Solar Electro-Optical Observing Network
SPACERAD	Space Radiation
SSS	Strategic Satellite System
STS	Space Transportation System
SWIR	Short-Wave Infrared
TAC	Tactical Air Command
TDA	Tactical Decision Aid
TOADS	Transportable Optical Atmospheric Data System
TOD	Technical Objectives Document
UV	Ultraviolet
VLBI	Very Long Baseline Interferometry
WWMCCS	World Wide Military Command and Control System

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